## Notes on some Points connected with the Progress of Astronomy during the Past Year.

### *Discovery of Minor Planets in* 1894.

Twenty-three new planets were discovered during the past year, as follows :—

| Provisional Designation. | Permanent Number. | Date of Discovery, 1894. | Discoverer. | Place of Discovery. |
|---|---|---|---|---|
| AQ | 379 | Jan. 8 | Charlois | Nice |
| AR | 380 | 8 | ,, | ,, |
| AS | 381 | 10 | ,, | ,, |
| AT | 382 | 29 | ,, | ,, |
| AU | 383 | 29 | ,, | ,, |
| AV | 384 | Feb. 11 | Courty | Bordeaux |
| AW | ... | Jan. 30 | Wilson | Northfield, Minn. |
| AX | 385 | Mar. 1 | Wolf | Heidelberg |
| AY | 386 | 1 | ,, | ,, |
| AZ | 387 | 5 | Courty | Bordeaux |
| BA | 388 | 7 | Charlois | Nice |
| BB | 389 | 8 | ,, | ,, |
| BC | 390 | 24 | Bigourdan | Paris |
| BD | | Nov. 1 | Wolf | Heidelberg |
| BE | | 1 | ,, | ,, |
| BF | | 7 | ,, | ,, |
| BG | | 7 | ,, | ,, |
| BH | | 19 | Borelly | Marseilles |
| BK | | 30 | Charlois | Nice |
| BL | | Dec. 1 | ,, | ,, |
| BM | | 19 | ,, | ,, |
| BN | | 28 | ,, | ,, |
| BO | | Apr. 9 | Roberts | Crowborough |

The letter BI was assigned to a planet discovered by Charlois on November 24, which was subsequently found to be identical with No. 369. AW and BO were discovered on photographs

taken for other purposes than the discovery of planets, the first being on a photograph of the *Pleiades* and the second on a photograph of the nebula H I 143.

Only one planet has received a name since the date of the last report, viz. No. 321, which has been named *Florentina*. An error in the last Report may be noticed here: the name of No. 316 should be *Goberta*, not *Roberta*, the latter being the name of No. 335, as given in the Report for the previous year.

The number 359 has been assigned to 1893 M, discovered by Charlois 1893 March 10.

The planet BE has an interesting orbit, its perihelion distance (1·60) being the smallest of the entire family, with the possible exception of 323 *Brucia*. Its least distances from the orbits of the Earth and *Mars* are about 63 and 21 millions of miles respectively. This planet is therefore well adapted for determining the Solar Parallax.

The planet No. 387 will be of about the 7th magnitude in favourable oppositions. No. 388 must have been close to 1892 S when the latter was discovered in 1892 December. The two planets, however, are not identical.

None of the nine missing planets enumerated in the last Report have been picked up. In addition to these, the following fourteen planets discovered in 1890 and 1891 have not been seen at any subsequent opposition :—Nos. 290, 293, 296, 307, 309, 310, 314, 315, 316, 318, 319, 320, 322, 323.

Professor Barnard has measured during the past year the diameters of *Ceres*, *Pallas*, and *Vesta* with the 36-inch equatorial at Mount Hamilton. His results have been already given in the *Monthly Notices* (vol. liv. No. 9). The diameters come out :— *Ceres* 520 miles, *Pallas* 304 miles, *Vesta* 241 miles. The great excess in size of *Ceres* over *Vesta* is surprising, and the latter planet must have a high albedo to account for its relative brilliancy. A. C. D. C.

## *Comets of* 1894.

The following comets have been discovered in 1894, and on some grounds are more than usually interesting.

Comet *a* 1894, by Denning.
Comet *b* 1894, by Gale.
Tempel$_2$ 1873, by Finlay.
Encke, by Perrotin, Wolf, Cerulli.
Comet *e* 1894, by E. Swift.

The first of these, discovered on March 26 in the constellation *Leo Minor*, was a faint object, and unfortunately growing fainter. The perihelion passage occurred about February 9, and the comet was increasing its distance from both Sun and Earth, so that notwithstanding a favourable position in the sky for ob-

servation, it has been somewhat inadequately observed. This is the more to be regretted, since the orbit is very interesting. Its ellipticity was early noted, though the period remained somewhat doubtful, and definitive elements are still wanting. From his first elements, M. Schulhof, pointed out that the orbit made a close approach, less than one-fifth of the Earth's distance from the Sun, to the orbit of *Jupiter*, in Hel. Long. 287°, and that in 1889 the two bodies had made a close approach. Further, that Tisserand's well-known criterion was satisfied in the case of two imperfectly observed comets—viz., 1743, I., and 1819, IV.—and the present comet. Later, M. Schulhof called attention to the fact that the point of closest approach between the orbits of *Jupiter* and the comet coincided very approximately with that of *Jupiter* and Brorsen's comet, and this fact has been further emphasised by Dr. Hind, who shows that the two comets, Denning and Brorsen, were actually near each other in 1881 April. Dr. Lamp, to whom we are indebted for the most accurate investigation of Brorsen's comet, shows that the two orbits intersect in Long. 284° 47′ and South Latitude 1°·57′, and that this point was passed by Brorsen on 1881, February 7, and by Denning 1881, March 14. This latter date depends on Schulhof's elements, which are still somewhat doubtful, and to secure the closest possible approach it would be necessary to diminish the mean daily motion found by Schulhof some 28″. This alteration seems large, implying as it does an error in the period of nearly half a year, but between the orbits of Schulhof and Hind there exists a still greater difference. M. Schulhof has employed an observation on May 22, while Dr. Hind's orbit rests on positions prior to May 6; this fact shows the importance of observations being continued as long as possible, but the Nice observation on June 5 appears to be the last.

For the second comet we are indebted to the energy of Mr. Gale, an amateur astronomer of New South Wales, and the discovery is an encouragement to all who work with small instruments, for Mr. Gale writes that he detected it with a 3-inch telescope. The comet was observed for a month at Windsor, N.S.W., Melbourne, &c., before it became visible in Europe, when, having reached its greatest brilliancy, it was a fairly conspicuous object in our western skies. A photograph taken at Paris on May 5, showed a tail 4° long, but the most complete study of its general features was made by Mr. Barnard at the Lick Observatory. A full account, with an admirable reproduction of one of the plates, appears in *Astronomy and Astro-Physics* for 1894 June. In the spectrum, which resembled that of the bright comet of 1893 (Rordame-Quénisset) more than twenty lines could be traced. The orbit shows no deviation from the parabola.

Tempel$_2$ 1873 comet, at its recent return was very unfortunately situated for observers in the Northern Hemisphere, rising about two hours before the Sun. More fortunately situated in the Southern Hemisphere, Mr. Finlay, of the Cape of

Good Hope Observatory, succeeded in finding it on May 8 by the aid of the ephemeris provided by M. Schulhof. The error in the assigned position was only nine seconds of right ascension and thirty seconds in declination, implying an increase of the mean anomaly of only 51″, a result upon which M. Schulhof may be congratulated, more especially when we remember that the comet has not been observed since 1878. The number of observations made at the Cape, at Windsor, N.S.W., and elsewhere is very few, owing to bad weather and the faintness of the comet, but the recovery of the comet after sixteen years is most satisfactory.

Encke's comet at its recent return was independently discovered by, at least, three observers. M. Perrotin at Nice obtained an observation on October 31 with the great equatorial, and described the comet as at the extreme limit of visibility in that telescope. On the same evening M. Wolf, at Heidelberg, secured a photographic record of the presence of the comet, but could not make any accurate determination of place. Dr. Cerulli, in Teramo, also saw the comet on November 1 as a faint nebulous object, but did not record the place with accuracy. These astronomers were assisted by the excellent ephemeris of Dr. Backlund, whose elaborate calculations on the motion of this comet have been highly appreciated, and whose intended withdrawal after his long supervision has been heard with so much regret. Not less valuable than the preparation of the ephemerides at each return of the comet is his determination of the mass of *Mercury* from the perturbations of this comet. In 1891, an approach to that planet was made, and the result of the discussion of the long series of observations has been to give a value, the most trustworthy, if the smallest, which has yet been assigned. This comet is still under observations and will be followed for some time longer in the southern hemisphere.

The last comet to be discovered was a very faint object, first seen on November 21 by Mr. E. Swift, of the Lowe Observatory, California (whither the Rochester Observatory has been removed). The comet was very faint, and like Denning's, had passed its perihelion, and was growing fainter. It had a considerable southern declination, but with northern motion; this advantage was, however, diminished by the growing faintness of the comet. Almost concurrently with the announcement of the discovery Dr. Berberich suggested the identity of the comet with the lost *De Vico*, and further examination and calculation support the suggestion. The arguments in favour of the identity are: the increase in the longitude of the perihelion and the decrease of that of the node, results which must follow the perturbation of a comet of short period with direct motion: the satisfaction of the Tisserand criterion; and the fact that both comets, supposing them to be distinct, were, according to the elements of Brünnow and Schulhof, respectively, in the neighbourhood of *Jupiter* in 1885, and that an increase in the period, such as that indicated, is likely

to result from the perturbations. It is to be hoped that the observations will be sufficiently numerous to permit a rigorous determination of the orbit, and the decision of this interesting question. So many comets have exhibited unexpected increase of brilliancy, notably that of Holmes, that it occasions less surprise that a comet should remain invisible for fifty years and once again become a recognisable member of the system.

In addition to these it may be mentioned that an object photographed during the solar eclipse of 1893 April 16, has in the last year been generally recognised as a comet. This fact recalls the observation made under similar circumstances in May, 1882, at Sohag, and suggests that many comets pass through their perihelia without being detected.

W. E. P.

## *Progress of Meteoric Astronomy in* 1894.

*January Meteors.*—At the epoch of the return of the *Quadrantids*, early in 1894 January, a very intense frost prevailed over England, and not many shooting stars were observed. A few were, however, recorded by Professor Herschel, at Slough, Mr. Corder, at Bridgwater, and Mr. Denning at Bristol. On January 2, at about $7^h$, Mr. Corder found the *Quadrantids* very active for a short time, the rate of apparition being about 40 or 50 per hour. He determined the radiant as at $219°+53°$ from 14 meteors, and found a neighbouring radiant in *Hercules* at $240°+48°$. A meteor of about second magnitude from the latter position was mapped both at Slough and Bridgwater on January 2 at $9^h\ 40^m$. It fell from a height of 65 miles above Cirencester, Glos., to 56 miles above Cranborne, Dorset, and traversed a real path of 53 miles with a velocity of about 21 miles per second.

*April Meteors.*—The moon was full on the 20th, and prevented successful observation. Mr. Corder watched for an hour on the 22nd with no result, and on the 23rd saw only 4 meteors in two hours. The only conspicuous *Lyrid* recorded at Bristol appeared on April 22, $9^h\ 59^m$, shooting from $260°+59°$ to $243°+72°$, and leaving a bright streak.

*May Meteors.*—On the mornings of May 1, 2, 4, 6, 7, and 10 Professor Herschel made a series of observations with a view to redetecting the fine shower of *Aquarids* discovered by Lieut.-Colonel Tupman in 1869. About 11 meteors of this system were mapped, but indicated a radiant not very sharply defined. Contemporary showers manifested themselves from the points $309°-17°$, $245°-20°$, $227°+47°$, and $25°+25°$.

*August Meteors.*—In the *Comptes Rendus*, 1894, No. 12, Padre F. Denza gave a summary of observations of shooting stars at 24 stations in Italy on the nights of August 9, 10, 11, and 12, the total number seen on the four dates being 1805, 5226, 2468,

2336 respectively, making an aggregate of 11835. At one of the stations, Montevergine, 4500 feet high, a fine display of *Perseids* was witnessed on the morning of August 11 at about 3 A.M., when shooting stars fell so plentifully that the exact number could not be counted. The chief position for the *Perseid* radiant, as determined at the Vatican Observatory, was at $45^\circ+54^\circ$, and minor showers revealed themselves in *Cassiopeia*, *Draco*, and *Cygnus.*

At Utrecht Messrs. Nÿland and Bolt noted 23 meteors within the 50 minutes from $12^h\ 22^m$ to $13^h\ 12^m$ on August 10. Of these 17 were *Perseids* with an apparently duple radiant at $38^\circ+57^\circ$ and $43^\circ+54^\circ{\cdot}5$. On August 13, from $13^h\ 30^m$ to $15^h\ 0^m$, the same observers counted 29 meteors, including 15 *Perseids.* A radiant in *Cassiopeia* at $22^\circ+53^\circ$ was also indicated from 5 meteors.

In England the weather of August was very unfavourable generally for meteoric observation. At Bridgwater the clouded skies prevented Mr. Corder from noting more than 8 *Perseids.* In July, however, he had redetected the *Aquarids* (usually forming a very pronounced display at the close of that month) and from 15 tracks found two radiants at $335^\circ-14^\circ$ and $338^\circ-3^\circ$. The prevailing atmospheric conditions during the *Perseid* epoch appear to have been more auspicious in the north than in the south of England, for Mr. E. R. Blakeley, at Dewsbury, obtained successful views of the shower on August 6, 9, and 10, and derived the radiant as follows:—On August 6 there were apparently two centres, $39^\circ+51^\circ$ and $40^\circ+56^\circ$ (14 meteors). On August 9, one centre, $42^\circ+56^\circ$ (15 meteors). On August 10 from $10^h\ 40^m$ to $12^h\ 10^m$ the directions conformed with a radiant at $45^\circ+55^\circ$ (24 meteors), while on the same night from $12^h\ 40^m$ to $14^h\ 0^m$ the radiation seemed different, and showed a major shower at $42^\circ+54^\circ$ (20 meteors), and a minor one at $40^\circ+59^\circ$ (8 meteors). Mr. Blakeley describes his radiants as pretty definitely marked. Mr. D. Booth, at Leeds, also noticed an apparent displacement of the radiant at different hours of the same night.

On August 10, $11^h\ 35^m$, a fine *Perseid*, nearly as bright as *Jupiter*, was recorded by Mr. T. W. Backhouse at Sunderland, and by Mr. Blakeley at Dewsbury. The pair of observations are in excellent agreement, and prove the meteor to have been unusually low in the atmosphere. When first seen it was 52 miles high over a point in the North Sea in lat. $54^\circ\ 16'$ N., long. $0^\circ\ 55'$ E., and disappeared at an elevation of 16 miles in lat. $53^\circ\ 55'$ N., long. $0^\circ\ 10'$ E.

On October 2, between $10^h$ and $11^h$, Mr. Corder noted a good flight of meteors from near *α Piscium.* In October and November the same observer recorded many slow meteors from a point in *Lacerta* at $323^\circ+53^\circ$. The *Taurids* were not very numerously in evidence, though twenty-five of them were seen, and there appeared to be three radiants at $55^\circ+27^\circ$, $57^\circ+22^\circ$, and $67^\circ+15^\circ$.

T

He also registered during the last week in October, and during November, 9 *Arietids* from $47° + 19°$, and 12 *Cetids* from $50° + 6°$. The October *Orionids* and November *Leonids* escaped suitable observation in consequence of brilliant moonlight. Between November 14 and 18 Professor Herschel watched the heavens during periods amounting in the aggregate to three or four hours, but not a single shooting star could be discerned in the partially clouded and moonlit sky. Mr. Corder, however, obtained glimpses of 4 *Leonids*, and of one or two *Andromedes*, but the weather was cloudy after November 25. The full Moon on December 12 interfered with the visibility of the *Geminids*, and no regular watches were undertaken at that period. The shower, however, appears to have returned pretty conspicuously on the morning of December 13, for an observer at Montreux (Suisse) says that at about 7.30 A.M. a considerable number of shooting stars were observed in the N.E. sky, not less than twenty being counted in about 10 minutes, after which the growing daylight prevented further observation.

*Fireballs.*—January 25, $10^h\ 1^m$. Detonating. Fell from 89 to 16 miles, over the Irish Sea to Tewkesbury. Real length of observed path 160 miles in 9 seconds (mean of 12 estimates). At Droitwich, Worcester, and other places in the Midlands the fireball caused a vibration like an earthquake shock, and people ran out of their houses in alarm. Radiant $331° + 55°$, near $\epsilon$ *Cephei* (see *Monthly Notices*, March 1894, p. 337).

February 8, $0^h\ 28^m$. Splendid meteor, observed in the sunshine of mid-day. Dr. A. A. Rambaut, of the Dunsink Observatory, witnessed the descent of the meteor, and collected a number of other observations, from which he found that, at first appearance, its height was 87 miles over the Irish Sea, and that at disappearance it had fallen to an elevation of 15 or 20 miles over a point near Leeds. Mr. W. H. Wood, of Birmingham, has also computed the real path of this body, and gives it as 80 miles above the Irish Sea to 17 miles above York; a result in substantial agreement with that deduced by Dr. Rambaut. The fireball moved swiftly from a radiant in *Hercules*.

February 21, $7^h\ 18^m$. Brilliant flashing meteor seen at Bristol, Dundee, North Lincoln, &c. The observations are not sufficiently full and exact to enable a reliable path to be computed. At its disappearance, however, the meteor seems to have been 30 miles high over a point near Bolton, Lancashire. It belonged to a radiant probably near $\theta$ *Ursæ Majoris*.

April 22, $7^h\ 36^m$. Large fireball observed in the evening twilight. It descended from 80 to 17 miles above Hastings to Amiens, France. Course, 120 miles in 4 seconds; velocity, 30 miles per second. Radiant not certainly defined by the observations, but somewhere in the region of $\alpha$ *Persei*.

August 26, $10^h\ 20^m$. Very fine meteor, moving swiftly, and giving a flash like vivid lightning, observed at many stations in the southern part of England. When first seen it was 90 miles

above a point in the river Mersey, and, travelling rapidly southwards, it ended its visible career at 30 miles above Ruthin, Denbighshire. Its observed course extended over 66 miles, and it left a very luminous streak, which was 9 miles long at first. This streak may justly be said to have formed the most remarkable meteoric apparition of the year. Its long duration, rapid drift in the higher region of the atmosphere, and successive transformations were among the more noteworthy features it presented. At many places it appeared, at first, as a phosphorescent bar, 2° or 3° long, and lying nearly vertical amongst the stars of *Ursa Major*. Quickly becoming convoluted, it drifted to S.E., and finally condensed into an irregularly shaped mass of nebulosity. At the moment of its first projection the middle of the streak was 54 miles high over a point 7 miles N.E. of Denbigh, and when last seen, 30 minutes after, by Mr. Corder at Bridgwater, it maintained the same elevation, but was then placed over a point 6 miles W. of Wolverhampton. This horizontal movement had therefore extended to 61 miles, so that the rate per hour was 122 miles, or 176 feet per second. At 10.37 it was seen by Mr. Packer, at King's Heath, near Birmingham, clouding the star $\iota$ *Draconis*, and at that time it formed a roundish mass 2° in diameter, which is equivalent to a real diameter of nearly four miles. The meteor belonged to a radiant at $305° + 79°$ near $\kappa$ *Cephei*, and there appears to be a well-defined shower of bright, swift meteors, often leaving streaks, from this point both in August and September.

Many other fireballs were recorded during the year, notably on May 18, August 20, September 8, 24, 26, 29, &c., but the observations were not sufficiently numerous and exact to allow the real paths to be computed satisfactorily. W. F. D.

## *Total Solar Eclipses.*

As only a few of the reports on the total solar eclipse of 1893 April 16 have yet been published, references to the results obtained are deferred until next year.

A Permanent Eclipse Committee of Fellows of the Royal and Royal Astronomical Societies has been formed for the consideration of the observation of future eclipses, and the discussion of records of those in the past.

## *Solar Activity in* 1894.

The principal feature of the solar activity in 1894 as compared with 1893 has been a distinct falling off in the mean daily spotted area. December 1893 had been an exceptionally active month, the mean daily area being larger than for any other month during the present cycle, except August 1893, and the number

T 2

of distinct groups and of separate spots being even disproportionately great. The decline which was witnessed in the early days of 1894 was therefore the more marked, and except for the appearance of a specially fine group towards the end of February, that decline continued until the end of March. A revival then set in, and the next four months showed very nearly as heavy a record as any similar period in 1893. From the end of July, however, a second decline has been manifest, and has continued with irregularities, to the end of the year.

There has also been a continuance of the decline in latitude already noticed in the previous year, and the southern hemisphere has maintained the predominance over the northern which had been a marked feature of 1893.

According to the figures given by Professor Tacchini, the area of the sunspots in 1894 was about 74 per cent. of that in 1893; according to M. Guillaume's results the proportion was as high as 87 per cent. Both agreed, however, that the faculæ of 1894 were only slightly inferior in extent to those of 1893, being over 90 per cent. The crest of the curve, therefore, appears to have been definitely passed, though both sun spots and faculæ still exceed considerably, both in number and area, the record for the maximum year of the previous cycle.

## *Solar Spectroscopy.*

At the meeting of the British Association at Oxford Professor Langley gave an account of his new methods for exploring and mapping the lines in the vast region of the solar spectrum which lies beyond the reach of the photographic plate in the infra red, and which, as is well known, has been rendered accessible for detailed study by the invention of the bolometer some fourteen years ago.

By the old method of working two observers at least were necessary, one to record the deflections of the recording galvanometer, and the other to read the angle determining the position in the invisible spectrum, whence any given thermo-electric disturbance arose. This process—which has been aptly described by Professor Langley as "a groping in the dark"—has now been entirely superseded, and a new and vastly improved form of apparatus has been constructed for the purpose of *automatically* recording with a high degree of accuracy both the intensity of any radiation falling upon the delicate bolometer thread and its wave-length.

In the new design the mirror attached to the needle of the galvanometer reflects a ray of light on to a photo-sensitised film, to which a vertical movement is given by clock mechanism, so that the horizontal swings of the needle are permanently impressed in the form of a curve on the film. The same

mechanism imparts a synchronous movement of slow rotation to the large rock salt prism, which forms the dispersion piece. In this way the entire spectrum is made to slowly drift past the bolometer thread (placed parallel with the lines in the spectrum), and the extremely sensitive galvanometer, which will betray a change of temperature amounting to only one-millionth of a centigrade degree in the thread, instantly responds to every variation in the energy of the radiation absorbed by the thread, as the invisible spectrum slowly moves over it; the spot of light reflected by the mirror tracing out, meanwhile, an "energy curve" on the moving film, the ordinate to this curve being proportional to the energy absorbed, and the abscissa being a function of wave length.

By means of another automatic process these bolograph energy curves are converted into ordinary lineal spectra, and any accidental disturbances arising from variations of temperature or of transparency in the atmosphere are eliminated by taking a number of bolographs of the same part of the spectrum and combining them by a process analogous to that of composite photography. The new bolograph has in this way already disclosed to us long reaches of spectrum as crowded with absorption lines as is the visible region, and extending down to a wave length of about seven microns. The large amount of detail which the apparatus is capable of revealing may be judged from the energy curve obtained, by way of trial, with the D lines in the visible spectrum. These are well separated, and show distinctly the nickel line between them.

We are now, therefore, entering upon a new era regarding this important work—the era of interpretation. The lines having been mapped over a length of spectrum equal to something like fifteen times that of the visible region, it now remains to study the relations which these lines bear to one another and to the various absorbing media of the solar and terrestrial atmospheres.

A further development of the spectro-photographic method of studying the solar surface, has, in the hands of M. Deslandres, yielded some new and important results. The interesting revelations which followed the first application of this method by Hale in America, as well as by Deslandres at Paris, were due to the particular ray selected, with which to obtain monochromatic images—namely, the centre of the K band. In this more recent work, however, M. Deslandres has obtained images from other dark lines, as well as from bright spaces in the spectrum. He finds that when the second slit of his spectro-heliograph is adjusted on some other dark line, or a little to one side of the centre of the K band, so as to avoid the bright reversals in the centre, but still keeping within the broad shade of that line, an image is obtained in which the faculæ are shown as clearly in the centre of the disc as near the limb; but they are less bright and less extensive than when the centre of K is used, and appear to correspond more closely with the faculæ as ordinarily seen, for the spots and penumbræ, so frequently veiled by the calcium radiation, are

well defined in these images, which are really images of the "reversing layer" between the chromosphere and photosphere.

It appears also that the smoke-like matter causing the general absorption near the limb must be situated below this layer, since these images are unaffected by it.

Monochromatic photographs obtained with the second slit adjusted on a bright space in the spectrum give images practically the same as by direct photography.

A detailed study of the double reversals of the H and K lines by the same investigator has revealed a curious want of symmetry between the bright and dark components of these lines in the general light of the sun. Thus, in 186 separate photographs of this region of the spectrum 120 clearly show a slight relative displacement between the central absorption line and the two edges of the broad and bright reversal on which the former appears to be projected. The bright edge on the side towards the red being in all these cases less distinct than the other edge, thus giving the central dark line the appearance of displacement towards the red. In spectra obtained from sections of the disc the two components of the reversal are sensibly equal in the brighter faculous region and also near the limb, but in all other parts of the disc this inequality prevails, the component on the red side being sometimes entirely absent.

In his persevering attempts to photograph the corona in full sunshine Professor Hale has again had to contend with discouraging circumstances. His latest experiments have been carried out on the summit of Etna.

The dark line K was selected by Professor Hale as the most suitable line for this work, although any other line might have served. Thus the line which has yielded such interesting results in photographing the chromosphere has again been pressed into service for the corona, but for a different reason.

Unfortunately at no time during Professor Hale's stay upon Etna were the atmospheric conditions so favourable as he had been led to expect, and the photographs he obtained show no evidence of true coronal forms. But this negative result will probably only lead to fresh efforts on his part to solve this interesting problem. J. E.

## *The Effective Temperature of the Sun.*

Hitherto the chief investigators in this line have been Chatelier and Rosetti. The former deduced the effective temperature of the sun by measuring the photometric intensity of the red light from solid bodies heated to different known temperatures, and obtaining an empirical law which held approximately between 700° and 1800° C. This method is to a great extent vitiated by the fact that the absorption by red glass probably decreases as the radiation increases, and that in calculating the

whole energy it is not well to experiment solely with a group of wave lengths. Rosetti found a law of radiation which held well up to 2000° C, and measured in arbitrary units the heat radiated from an incandescent body at a known high temperature by means of a thermopile and galvanometer, and compared it with the heat coming from the sun by the same means. His empirical formula was $y = aT^2(T-\theta) - b(T-\theta)$, where $y$ is the thermal effect of the radiation as given by the deflections on the scale of the thermopile, T is the absolute temperature of the radiating body, and $\theta$ that of the surrounding medium. This equation approximates to a law of the third power for very high temperatures. MM. Wilson and Gray, by employing a Joly's meldometer and a Boys' radio-micrometer, arrived at results which are more accurately given by a law of the fourth power. The result gives the effective temperature of the sun as 6200°C.; or, utilising the researches of MM. Wilson and Rambaut on the absorption of heat by the sun's own atmosphere, approximately 8700°C. Later experiments by MM. Wilson and Gray point to the fact that the same law does not hold for blacked and bare platinum, and this will probably influence the determination of the sun's temperature by a few hundred degrees. A. S. D. R.

## *The Transit of Mercury.*

The transit on November 10 was well observed in America, and a few observations were also secured elsewhere, even in the British Isles, though ingress occurred very shortly before sunset. The observers with great unanimity failed to see any ring of light round the planet, white spot on the disc, or satellite, and almost the only noteworthy remark is made by Professor Young, who has on this and three previous occasions noticed a peculiar "hardening" of the Sun's limb just before external contact, which "may be due to the planet's obscuration of the brightest part of the chromosphere close to the disc of the Sun, or to some diffraction effect at the limb of the planet."

## *The German Heliometer Observations of the Transits of Venus, 1874 and 1882.*

Dr. Auwers has published volume v. of the series devoted to these observations. In previous volumes the observations themselves have been given; in this the final discussion is made. The first fourteen chapters (459 pages quarto) deal with the determination of the instrumental constants, division errors, screw errors, temperature corrections, zero of focus, scale value from stars, &c. The main results of chapters xv. and xvii., which deal with the measures of diameter of the Sun and *Venus*, were published some time ago, and were noticed in the Council

Report for 1892 (*Monthly Notices*, lii. p. 279). Chapter xii. deals with the Meridian places found specially at a large number of observatories, and places in existing catalogues, of a number of stars measured by the heliometers for scale value; and the comparison of material collected from so many sources, conducted with Dr. Auwers's well-known skill, is of great value, independently of this particular research.

The discussion of the actual observations of the transits of *Venus* is contained in chapter xvi. (113 pages), and the final parallax deduced from the two transits is $8''\cdot896 \pm 0''\cdot0216$.

## *The Recent Opposition of Mars.*

Although the greatest apparent diameter of *Mars* was less in 1894 than in 1892, being only $21''\cdot7$, as compared with $24''\cdot8$, yet the planet was much more favourably placed for observers stationed in our northern hemisphere, it having considerable north declination. So that, judging from the accounts already published, it is probable that the results obtained will equal, if not surpass, those of any preceding opposition in importance. Some of the chief points concerning the work of the past opposition may be shortly enumerated as follows:

1. The complete disappearance of the south polar spot as a visible object.

2. Numerous observations of irregularities at the terminator of the planet when it was gibbous, consisting of (*a*) small bright projections, usually in connection with a bright region just within the terminator. (*b*) Flattenings or slight hollowings of the curve of the terminator, generally at those parts where the darker regions were passing out of sight.

3. A very general confirmation of the canal system of Schiaparelli.

4. The duplication, or gemination, of a number of the canals, even at about the time of the summer solstice of the southern hemisphere.

5. Further extension of the work of Schiaparelli by the detection, chiefly at Mr. Lowell's observatory, of many additional canals and other delicate details, and of a number of minute dark spots or lakes, the latter often being curiously situated at the points where two or more canals meet or cross each other.

6. One of the most important results of the past season is certainly that relating to the presence of cloud. During recent years the opinion seems to have been gaining ground that the atmosphere of *Mars* is almost free from clouds, and that even when visible they are not of any great extent or density. But during the latter half of October last nearly the whole of the Maraldi Sea, and the extensive continental area extending north of it up to about 20° north latitude, were densely obscured by

cloud, the region affected having an area of at least 6,000,000 square miles, considerably greater than that of the whole of Europe.

7. Additional evidence in favour of actual change. For instance, the disappearance of a considerable part of the bright region named Aurea Chersonesus has been independently noted by several observers, the continental outline here being much changed from what it was in 1877, according to the maps of Mr. Green and Professor Schiaparelli.

8. Professor Campbell undertook some observations of the spectrum at the Lick Observatory, but did not succeed in confirming the earlier observations of Huggins, Rutherfurd, Vogel, and others in finding evidence of absorption due to an atmosphere.

A. S.-W.

## *Jupiter.*

The fifth satellite remains so far the property of the discoverer that the only measures of it published during the year have been those by him. He has, however, kept a careful watch upon it, and the collected observations published in No. 325 of the *Astronomical Journal* afford material for a good determination of the orbit. The periodic time deduced is $11^h\ 57^m\ 22^s{\cdot}618 \pm 0^s{\cdot}013$; and is thus satisfactorily confirmed by the observations of Dr. Herman Struve at Pulkowa, in 1893 October (*Ast. Nach.* No. 3200), who deduced a period of $11^h\ 57^m\ 22^s{\cdot}58$ from an observed East elongation, compared with Marth's Ephemeris. Dr. Struve could recognise the satellite up to $5''$ from the limb, but Professor Barnard has not recorded *measures* within $11''$ of the limb. In the exhaustive paper above referred to, Professor Barnard deduces a mean distance from East elongation only during 1893, of $47''{\cdot}785 \pm 0''{\cdot}044$, at the geocentric distance 5·20 of *Jupiter*. No observations could be obtained at West elongation during 1893, but seven series were obtained in 1892, giving a mean distance $47''{\cdot}712 \pm 0''{\cdot}176$, as compared with $48''{\cdot}104 \pm 0''{\cdot}061$ from fourteen East elongations in 1892. Professor Barnard concludes that the orbit is really eccentric; and M. Tisserand has shown that the major axis must make a complete revolution in about five months. In *Ast. Nach.* No. 3267, Professor Barnard gives eight observations at West elongation on 1894 October 8, which are "the only observations he has been able to secure, though the satellite has been seen at another time; at these measures it was extremely faint." The discoverer proposes to retain the name Satellite V, remarking that if the order of discovery instead of that of distance from *Jupiter* be regarded as the criterion, the numbers I., II., III., IV., V., are probably consistent. In measuring the satellite he has incidentally measured the diameters of *Jupiter*, and finds for the

| | | |
|---|---|---|
| Equatorial diameter | $38''{\cdot}522$ | (at $\Delta$ 5·20) |
| Polar diameter | $36{\cdot}112$ | „ |

which are about 1″ greater than heliometer measures. This systematic difference he attributes to the faulty nature of the images formed by half an object-glass in the heliometer.

Professor Newcomb has discussed* the orbit of Polyhymnia (33) and the mass of *Jupiter*, and finds for the reciprocal the mass 1047·34, which agrees well with the weighted mean (1047·35 ± 0·065) of all existing determinations.

At the end of 1893 Professor Barnard found the first satellite of *Jupiter* to have dusky poles and a bright equatorial belt,† thus confirming and explaining a previous observation in 1890, when the satellite was seen elongated. This discovery, indeed, seems to be a satisfactory explanation of several previous and mutually contradictory observations. The satellite has been announced as *ellipsoidal*, or as *double*. It is easy to see how an imperfect appreciation of the facts as now announced by Professor Barnard might lead to these interpretations of what was seen.

## *The Satellite of Neptune.*

Dr. Hermann Struve's observations and their discussion form the subject of a memoir in Volume xlii. of the *Memoirs of the Imperial Academy of Sciences*, St. Petersburg. The observations extend over the period 1886-1893, and were made in such a manner as to exclude as far as possible systematic errors of personality and methods of observation. Thus, in measuring the position angles, he resorted to three different methods: (1) by the use of a single bright wire in a dark field; (2) a dark wire in a bright field; (3) two close parallel wires; further, he always so arranged that the line joining the planet and satellite should be either parallel or at right angles to the line joining his two eyes. The use of a single wire proved the more accurate. To make the mean times of observation in angle and distance coincident, the angles were observed in two sets, the distances being intermediate. These methods in connection with observations of twenty double stars made for the purpose, form groundwork for a thorough investigation of systematic errors. The distances were also examined thoroughly. The powers used were 515, 630, and 900.

For discussion of the observations they were divided into four groups, giving eight groups of equations (the polar formulas of Marth) and corrections to the assumed elements deduced from each series independently, the accordance of the results being eminently satisfactory. For instance, the values of the mean distance of the satellite are—

* *Ast. Nach.* No. 3249.

† *Monthly Notices*, liv. p. 134.

| | |
|---|---|
| 1887·62 | $a = 16''{\cdot}285 \pm 0''{\cdot}028$ |
| 1889·02 | $16{\cdot}272 \pm \cdot019$ |
| 1890·61 | $16{\cdot}253 \pm \cdot021$ |
| 1892·60 | $16{\cdot}203 \pm \cdot032$ |

In deducing the mean motion of the satellite in its orbit, and also the motion of the plane of the orbit, Dr. Struve has used observations by Lassell, Bond, and O. Struve. The motion of the node which was first pointed out by Mr. Marth in vol. xlvi. of the *Monthly Notices* is confirmed, and Dr. Struve finds that the old and new determinations can be represented by—

$$N = 185^\circ{\cdot}15 + 0^\circ{\cdot}148\ (t - 1890)$$
$$I = 119{\cdot}35 - 0{\cdot}165\ (t - 1890)$$

where N is node on equator and I the inclination. This motion, M. Tisserand points out, could well be accounted for by supposing a polar compression for the planet of $\frac{1}{100}$.

The elements of the orbit are—

| | |
|---|---|
| Longitude of Satellite reckoned from the node ... ... | $234^\circ{\cdot}42$ |
| Mean daily motion ... ... ... ... ... | $61{\cdot}25748$ |
| Node (referred to equator) ... ... | $185{\cdot}15 + 0^\circ{\cdot}148\ (t - 1890)$ |
| Inclination (referred to equator) ... | $119{\cdot}35 - 0{\cdot}165\ (t - 1890)$ |
| Semi-axis major (at distance whose log is 1·47814) | $16''{\cdot}271 \pm 0''{\cdot}012$ |
| Eccentricity ... ... ... ... less than | 0·01 |

The orbit is thus very nearly circular.

As incidental to the chief work, Dr. Struve finds—

(1) Mass of Neptune $\dfrac{1}{19396 \pm 43}$

| | | |
|---|---|---|
| (2) Diameter of Neptune— | yellow field | $2''{\cdot}120$ |
| | Bright red | 2·197 |
| | Dark red | 2·273 |

Professor Barnard has published (*Astronomical Journal*, No. 314) his observations of the satellite with the Lick telescope during the opposition of 1893-4.

T. L.

*Double Stars.*

The Society showed its appreciation of this branch of astronomy by presenting, in February 1894, its Gold Medal to Mr. S. W. Burnham for his discoveries, micrometric measures, and general work in connection with it. Since then Volume II. of

the Lick Observatory Publications has been issued, wherein is collected a great proportion of Mr. Burnham's recent work. It is a large and well-arranged volume and, from the following selected contents, is readily seen to be essential to double-star workers :

(*a*) Frontispiece showing the micrometer used with the 36-inch refractor.
(*b*) Measures of planetary nebulæ.
(*c*) Burnham's 14th, 15th, 16th, 17th, 18th, 19th catalogues of new double stars.
(*d*) Micrometer measures of known doubles.
(*e*) Work on star orbits.

Another publication which is welcome, both for its contents and its speedy issue, is Professor S. Glasenapp's "Observations Astronomiques faites à Abastouman," from 1892 August to 1893 May. These observations are in continuation of those made at Hoursouf. This is the second occasion on which Professor Glasenapp has journeyed southwards to secure the much-needed observations of southern doubles. There are 1220 measures of 610 pairs. The volume also contains such incidental work as occultations, lunar eclipse 1892 November 4, places of Comet Holmes, estimations of the variable stars $\nu$ *Arietis*, $\beta$ *Lyræ*, $\mu$ *Aquilæ*, *Algol*, &c.

The only other collection of measures is that of 117 pairs made at the Royal Observatory, Greenwich, with the $12\frac{3}{4}$-inch Merz refractor, and published in the *Monthly Notices* 1894 March.

Amongst the works on double stars are Professor A. Hall's "Résumé of Different Methods of Computing Double-star Orbits" in the *Astronomical Journal* 1894 August 16 ; Professor W. Schur's "Re-determination of the Orbit and Parallax of 70 *Ophiuchi* (parallax $0''\cdot286 \pm ''\cdot031$)," "A Method of Computing a Double-star Orbit from Spectroscopic Observations of Motion in the Line of Sight," by Lehmann Filhés, in the *Astronomische Nachrichten*, 2242. Then Mr. Burnham's paper in *M.N.* 1891 April has called forth the pamphlet "Ueber den Vierfachen Stern $\zeta$ *Cancri*," in which Professor Seeliger * collects all the recent measures of this system, and shows that the undulatory motion of the distant companion C is still in evidence, and contends that no hypothesis of systematic errors due to personal equation can account for the recurrence of four revolutions (18-year period). At Georgetown College a year was spent in experimenting with a photochronograph attached to a 12-inch refractor, the object being to obtain a number of photographic images of a pair on a plate and also to derive at once a scale value. Fifteen pairs were thus photographed. These were wide pairs, and the labour involved seems scarcely to be repaid by the result.

* A translation of this will be found in *Astronom yand Astro-Physics*, 1894 December.

The orbits computed during the year are—

| Star. | Period (in Years). | Computer. | Where Published |
|---|---|---|---|
| OΣ 82 | 90·54 | J. E. Gore | *M.N.* 1894 June. |
| OΣ 224 | 96·13 | J. E. Gore | *Astronomy and Astro-Physics*, 1894 Aug. |
| β 101 | 23·33 | S. Glasenapp | *M.N.* 1894 March. |
| β 416 | 27·66 | S. Glasenapp | Roy. Soc. N.S. Wales, 1894 June 6. |
| 70 Ophiuchi | 88·40 | W. Schur | A.N. 3220–21. |
| η Cassiopeiæ | 208·1 | T. Lewis | *M.N.* 1894 November. |
| Sirius | 50·99 | C. P. Howard | *Astronomy and Astro-Physics*, 1894 June. |
| Sirius | 51·97 | S. W. Burnham | Vol. II. Lick Publications. |
| κ Pegasi | 11·37 | S. W. Burnham | ,, ,, ,, |
| τ Cygni | 36·5 | S. W. Burnham | ,, ,, ,, |

T. L.

## *Nova Normæ.*

A very interesting light was thrown upon the enigma offered by *Nova Aurigæ* by the discovery on one of the plates taken in the course of the Southern Spectroscopic Survey of Professor E. C. Pickering, of a new star bearing a striking resemblance in its spectrum characteristics to the earlier spectrum shown by *Nova Aurigæ.* The plate on which this new stellar spectrum was first seen was taken at Arequipa on 1893 July 10, and the spectrum detected by Mrs. Fleming during her examination of the plate at Harvard College on 1893 October 26. The star had been of about the 7th magnitude on July 10, and plates taken of the same region a few weeks earlier show that it could not have been as bright as the 14th magnitude on May 27, nor as the 10th on June 21. It must therefore have attained its brightness pretty rapidly. It had diminished greatly in brightness before direct visual examination could be begun, and it was only of the 10th magnitude when Professor Campbell examined its spectrum in February and March 1894. Professor Campbell's observations led him to conclude that just as its first spectrum resembled that of the first spectrum of *Nova Aurigæ,* the lines of the hydrogen series being seen double, a bright line and a dark side by side, so now, as in the case of *Nova Cygni,* its spectrum had become distinctly nebular. The importance of this is the probability it affords that both *Nova Aurigæ* and *Nova Cygni* are typical "temporary" stars even in their most characteristic details of spectrum. The place of the star for 1900 is R.A. $15^h\ 22^m\ 12^s$, Decl. 50° 13′·8 S.

*Lockyer's Photographic Spectra of some of the Brighter Stars.*

An important memoir on the above subject was laid before the Royal Society by Professor J. Norman Lockyer in 1892 November, and published about a year ago. The work to which it related included the taking of 443 photographs of 171 of the brighter stars. The method adopted was in the main that of the object-glass prism, the aperture usually employed being no more than 6 inches. With a prism of 45° exquisite photographs were obtained, giving spectra two inches in length from F to K, which bore a high degree of enlargement very satisfactorily.

The discussion of the photographs leads to their classification in four orders: (1) Spectra with no marked continuous absorption in the ultra-violet or violet; (2) Spectra where the absorption is marked in the ultra-violet, and extends to K; (3) Spectra where it extends to G; and, (4), four other stars, $\gamma$ *Cassiopeiæ*, $\beta$ *Lyræ*, P *Cygni*, and *Nova Aurigæ*. The classification is further extended to subdivisions of these orders, characterised by differences in the appearance of the principal lines, and tables are given of the wave-lengths of the strongest lines observed. The deductions Professor Lockyer draws from these photographs are in support of his Meteoritic hypothesis, and especially of his contention that there is evidence of the existence of stars of increasing temperature, as well as of decreasing. A number of reproductions of the very beautiful photographs obtained in the course of the work accompanies the paper.

*The Spectra of $\beta$ Lyræ and $\delta$ Cephei.*

The many recent investigations of the spectrum of $\beta$ *Lyræ* may be regarded as supplementary to those on *Nova Aurigæ*, the analogy between the two objects being so close that legitimate conclusions regarding one might pretty safely be extended to the other. The most important of these researches was conducted at Potsdam. It was based upon 144 spectrograms obtained by Dr. Wilsing with the International photographic telescope. The plates employed being sensitive up to $\lambda$ 380, showed, for the first time, the ultra-violet part of the spectrum, which included all the more refrangible hydrogen lines, dark and bright. The solar prominence line, K, was also brilliant with a dark duplicate. The components of these and other coupled lines shifted their relative positions coincidently with the star's light-change, yet with evident outstanding disturbances, possibly comprised in a period extending over some years. Dr. Vogel's elaborate discussion of the subject was presented to the Berlin Academy of Sciences on 1894 February 8.

The Potsdam photographic results are in most satisfactory agreement with Professor Keeler's visual observations made with

the great Lick refractor in 1889, but only published in *Astronomy and Astro-Physics* for 1893 April. They related chiefly to the $D_3$ line. They proved besides that the variability of *β Lyræ* depends upon the fading and brightening of its continuous spectrum.

M. Bélopolsky's investigation appeared in the *Memorie degli Spettroscopisti Italiani*, for 1893 June, *t.* xxii. It is distinguished by some special features; first, the plates used being orthochromatic, the portion of the spectrum examined stretched from D to Hγ. Next, the twenty-five plates discussed were exposed with the Pulkowa 30-inch refractor. Finally, and above all, a comparison-spectrum of hydrogen, iron, or sodium, was photographed simultaneously with the star's spectrum. Absolute measurements from the fiducial lines thus afforded appeared to assign nearly the whole of the motion-displacements to the bright lines, the shiftings of which to and fro are performed as nearly as may be synchronously with the general light-change—that is, in a period of 12·9 days. The phases of the hydrogen F are noted by Dr. Vogel to be in complete accordance with those of Hζ, the ultra-violet line in which they are most characteristically marked.

Father Sidgreaves, in a paper inserted in the *Monthly Notices* for 1893 December, derived confirmatory results from forty-five spectrograms taken with the old eight-inch refractor of the Stonyhurst observatory. It appeared to him that the bright lines are at their maximum strength during the first three days after the principal minimum.

Prof. Norman Lockyer, on the contrary, regarded them as brightest soon after the secondary minimum. The materials for his research were furnished by forty-five spectrograms of *β Lyræ* taken at South Kensington with a six-inch object-glass prism fitted to a telescope of the same size; and a summary of its results, having been first communicated to the Royal Society, was published in *Astronomy and Astro-Physics* for 1894 August. The photographs showed: (*a*) periodical changes in the relative intensities of the lines; (*b*) periodical doublings of some of the dark lines; (*c*) periodical changes in the positions of the bright lines with respect to the dark ones. He inferred the presence of two bodies giving dark-line spectra, the greatest relative velocity of which in the line of sight is about 156 miles a second; and, further, the strong resemblance of one of these to *Rigel*, and of the other to *Bellatrix*. Shifting bright lines are superposed upon the double absorption spectrum; but all spectral variations bear a constant relation to the general period of the star.

Prof. Lockyer, as well as M. Bélopolsky and Father Sidgreaves, account for the two-fold obscuration of *β Lyræ* by partial eclipses occurring when the two bodies believed to compose it are situated in the line of sight from the Earth. But, according to Dr. Vogel and Professor Keeler, an eclipse-hypothesis is negatived by the fact that at the epoch of principal minimum, the coupled lines

are at their maximum of separation. In other words, the stars, instead of being in conjunction, are at elongation. Thus, the problem presented by this star remains for the present unsolved. Its interest has, if possible, been heightened by M. Bélopolsky's announcement (*Astr. Nach.* No. 3257) that $\delta$ *Cephei*, too, is a spectroscopic binary, completing its revolutions in the identical period of its light-phases. His results, however, are to be regarded as only provisional. All short-period variables may, perhaps, before long come to be regarded as multiple systems.

A. M. C.

## *Star Catalogues.*

On his return from the Cape of Good Hope and appointment to the Directorship of the Radcliffe Observatory, Oxford, Mr. Stone determined to carry into the northern hemisphere the general survey of the stars which he had completed for the southern hemisphere in his *Cape Catalogue*, 1880. For fourteen years (1880 January 1 to 1893 December 31) the transit-circle of the Radcliffe Observatory has accordingly been devoted to the observation of stars to about the seventh magnitude, distributed over the northern hemisphere, and the result is a catalogue of 6424 stars between the North Pole and 115° south declination, some being included which are a little further south. There are roughly 29000 square degrees in the portion of the heavens surveyed, giving an average of rather less than one star to a photographic plate (four square degrees) as planned by the International Conference. Such a comparison reminds us of the magnitude of the astrographic scheme.

The epoch of the catalogue is 1890. Proper motions have been deduced in all cases, where comparison with previous catalogues shows them to be large, and the reference numbers to six such catalogues, commencing with Bradley (1755) and ending with Greenwich (1880) are given. In a brief introduction, Mr. Stone points out that the systematic errors of the catalogue cannot be large.

Observations of the Sun have been made during the years 1884–91, and discussed separately year by year, as well as by grouping the whole series; and an epoch correction of $+0^s{\cdot}014$ adopted. The flexure, as determined by the horizontal collimators, was very steady, the coefficient being confined within the limits $1''{\cdot}25$ and $1''{\cdot}10$. A discussion of circumpolar observations affords evidence for a slight diminution of Bessel's mean refractions, which has not, however, been applied. The correction to adopted colatitude was found insensible.

The work "owes its existence" not only to the untiring energy of Mr. Stone and the staff of the Radcliffe Observatory, but "to the liberality of the Radcliffe Trustees."

Vol. xvii. of the *Results of the Argentine National Observa-*

*tory*, and the twelve maps referred to in the last Report, have been published during the year.

M. Nyrén has published a Catalogue of Mean Declinations of 450 fundamental stars, observed with the Pulkowa Vertical Circle, during the years 1882–1891. The epoch of the Catalogue is 1885. A comparison with the similar Catalogue for 1865 is given in a brief introduction.

The *Cape Catalogue* (1885–90) has also been published, but has not yet been received by the Society.

A five-year catalogue of 258 fundamental stars for 1890 has been published by the Astronomer Royal, and the places used in the *National Almanac* for 1896.

A volume of the Revision of the *Durchmusterung* has been published by the Bonn Observatory (+40° to +50°, 18457 stars).

## *Spectroscopic Observations of Nebulæ.*

An important paper by Professor Campbell on the spectra of the *Orion* and other nebulæ, appeared in *Astronomy and Astro-Physics* for May last. Professor Campbell gives tables of bright lines photographed in the *Orion* nebula, of dark lines photographed in *Orion* stars, and of the comparison of bright nebular and dark star lines. He comes to the conclusion that "nearly all the dark lines in the faint stars are matched by bright lines in the nebula, but there is no reason known at present for supposing that the prominent nebular lines λ5007, λ4959, λ4346, λ3869, λ3727 are matched by dark stellar lines. They appear to remain characteristic of the nebular spectrum. The fact that some or all of these positions are not occupied by dark lines renders it doubtful whether any of the lines are due to absorption by the nebula proper, and we cannot say that these stars are beyond the nebula or are physically connected with it. We may say that they are closely related to the nebula in chemical constitution, and relatively closely in physical constitution."

In the continuation of this paper Professor Campbell gives the results of visual and photographic observations of six planetary nebulæ, combining the whole result in a table which gives in parallel columns the bright lines of the *Orion* nebula, and of the planetary ones. "The prevalence," he says, "of the same lines in these nebulæ is very noticeable, and it would be found to be much more general if the nebulæ were more nearly of the same density, so that equivalent exposures could be made." There are a few points of correspondence between the nebular spectrum and that of the Wolf-Rayet stars, but there are so many points where correspondence is lacking that we cannot say the two types are closely related.

Professor Keeler's spectroscopic observations of nebulæ made at the Lick Observatory have appeared in full in the last volume

of the *Publications* of that observatory, The following are the principal conclusions at which he arrives :

1. The normal position of the chief nebular line is λ5007 ±0·03 on Rowland's scale.

2. The normal position of the second line is λ4959·02±0·04. This line is 1·39±0·04 tenth-metres less refrangible than the centre of the double line of iron at λ4957·63.

3. The first and second nebular lines are not represented by absorption lines in the solar spectrum, as shown in Rowland's map.

4. The relative brightness of these two lines is, within the limits of error of estimation, the same for all nebulæ. Hence there is reason for thinking that they are due to the same unknown substance, perhaps an element of somewhat the same nature as the so-called helium.

5. The spectrum of the bright line nebulæ indicates either a high temperature of the gases emitting the light, or a state of strong electrical excitement, and shows that the temperature and pressure are greatly increased at the nucleus.

6. The distance between the great nebula of *Orion* and the Sun is increasing at the rate of 11±0·8 miles per second.

7. No relative motion of different parts of the *Orion* nebula could be detected.

8. The nebulæ are moving in space with velocities of the same order as those of the stars. Of the nebulæ observed, G.C. 4373 has the greatest motion of approach, namely, 40·2 miles per seeond ; and N.G.C. 6790 the greatest motion of recession, 30·1 miles per second.

10. The visible spectrum of the nucleus of a planetary nebula has in many cases a resemblance to that of stars of the Wolf-Rayet class, though the two principal nebular lines are absent from the latter.

In a paper on the continuance of his observations on the spectra of nebulæ made at the Allegheny Observatory, Professor Keeler gives a table of the wave-lengths of the bright lines measured on photographs of the spectrum of the *Orion* nebula, and a second table of the positions of the dark lines in the spectra of the trapezium stars, also of the lines in the lower spectrum of *Rigel*. He discusses at length a comparison of the bright nebular lines with the dark lines in the spectra of the *Orion* stars, and concludes that these demonstrate the intimacy of the relation which exists between the *Orion* nebula and the neighbouring stars—indeed, "the spectrum of *Rigel* may almost be regarded as the nebular spectrum reversed." According to Professor Keeler, while the relation to the nebula of the trapezium stars is more certain than ever, they can no longer be regarded as necessarily situated in the nebula. The broadness of the hydrogen absorption lines precludes the supposition that the absorption is due to the nebula itself, and the stars may therefore, within indefinite limits, be placed anywhere in the line of sight.

## *The Potsdam Photometry.*

The most recent and most complete of modern researches on the visual magnitude of the stars has lately been brought to the conclusion of its first stage. Doctors Müller and Kempf, of Potsdam, have published* their observations of the brightness of all stars in the zones 0° to +20° declination whose magnitude is not recorded as fainter than 7·5 in Argelander's Durchmusterung, 3522 stars in all. Within a few years they hope to complete this survey to the North Pole. The photometer chosen is that of Zöllner, three different instruments adapted to stars of different brightness being used. A list of 144 fundamental stars well distributed throughout the sky was first prepared and the determinations of their brightness carried to an extreme degree of accuracy, discussions being made of the influence of colour in the star and of personality in the observer. With these as reference points, the general mass of the stars was examined in short zones of twelve stars each, a pair of standard stars being measured at the beginning, in the middle, and at the end of each zone; the magnitude of every star was determined once by each observer, and the accordances are so close as to justify the observers in regarding their work as a considerable advance not only in scope but in accuracy on anything that has been done before. The final catalogue of 3522 stars gives a reference to the B.D., the R.A. and declination for 1900, the B.D. mag., the separate determinations by the two observers, with references to the zones where their original observations are to be found, a compendious note on the colour of the star, and other remarks of interest. The arrangement of the work leaves, in fact, nothing to be desired in the way of completeness and facility of reference Finally a comparison is made between the present work and the Oxford and Harvard Photometries, cases of large discordance being carefully noted.

## *The Astrographic Chart.*

As no *Bulletin du Comité Permanent* has been published during the year, all our information on the progress of the photographic mapping of the heavens is derived from a few scattered notices and reports of observatories. Seven of the associated observatories have already taken more than half the number of catalogue plates assigned to them. There is every reason to hope that all the photographs for the catalogue—with the possible exception of those allotted to the South American observatories—will be completed in two or three years time. The number of chart (long exposure) plates taken is, however, much smaller, and at the present rate of progress, this part of the work

* *Potsdam Observatory Publications*, vol. ix.

will not be completed by 1900. No reproductions of the plates have yet been published.

In the work of measuring the catalogue plates the French observatories have taken the lead. At the beginning of the year seventy-two plates had been measured at Paris and thirty-eight at Algiers, and the work is in full progress. Several other observatories have begun this laborious task, but there are at present no means for assigning even an approximate period for its completion. During the year a memoir has been published by M. Anders Donner, on the reduction of the measures of the Helsingfors plates; and two notes have appeared in the *Monthly Notices* in which the simple linear method of reduction given by Professor Turner in 1893 November, is practically applied.

We report with regret the deaths of Father Denza and M. Maturana, directors respectively of the observatories of Rome and Santiago, both of which are co-operating in the work of photographing the heavens. F. W. D.

## *Astronomical Photography.*

The rapidly increasing importance of the photographic method would seem to make it especially desirable to summarise the history of the year. There is, however, a peculiar difficulty in so doing. The questions of the systematic reproduction of photographs, and of the form in which measures, made on plates which it is not intended to reproduce, shall be given, are not yet settled; and anything like a complete knowledge of what has been done during the year is thus almost impossible. In future Reports of the Council it is hoped to deal more fully with such a summary. For the present it may be mentioned that in volume iii. of the *Lick Observatory Publications*, there are some beautiful enlargements of lunar photographs taken with the 36-inch refractor, stopped down to 8 inches; that Dr. L. Weinek, who made the enlargements, has also published some equally fine enlargements of lunar negatives taken by MM. Lœwy and Puiseux at Paris; that Dr. Roberts has published his photographs of star clusters and nebulæ, which are referred to elsewhere; and that Professor Barnard of the Lick Observatory has sent to this Society sixty positives of stars and comets, the publication of which is under consideration by the Society.

The Council of the Society have further determined to consider fully the question of reproduction of photographs, with the view of acting as a centre for distribution of permanent copies at approximately cost price. The details are under consideration, and it may take some time to arrive at a final plan of procedure; but if the Council have rightly estimated the advantages of such a scheme, it cannot be made generally known too early. Information and advice from others will be cordially welcomed, and can

not fail to be of the greatest assistance in organizing the systematic reproduction of photographs.

*Variation of Latitude.*

Several papers of considerable importance in connection with the variation of latitude have been published during the year. Mr. Chandler has reduced and discussed the observations made by Pond at Greenwich in the years 1825 to 1835 with two mural circles. "This beautiful series of observations may be regarded as one of the most remarkable in modern astronomy. Hitherto, however, astronomy has not reaped its benefits from the fact of Pond's inadequate reduction of them." Pond's device was to observe a star directly with one instrument and by reflection with the other at the same culmination, reversing the arrangement on another night. Mr. Chandler selects 7176 combinations of thirty-six stars, and after carefully investigating the systematic errors of refraction, possible temperature effect on runs, &c., uses this valuable material for determining the oscillation of latitude, which satisfactorily corresponds with his tentative hypothesis. The continuation of the series from 1836 to 1851 under Airy's directorship, though not so homogeneous, is also discussed, yielding 4353 observations. This is the last of the individual series of observations successively examined by Mr. Chandler, and he has proceeded to make a definitive discussion of the whole. The results may be briefly stated as follows:

There are two terms of latitude variation, whose periods are respectively one year and 428·6 days, and whose mean coefficients are equal, each being 0″·135; but both the epochs and coefficients of these terms are affected by a slow oscillation in a period of about sixty or seventy years, the amplitude of the oscillation for the 428-day term being about 0″·1, and of the annual term about 0″·05; it is suggested that the pole rotates, not in a circle, but in an ellipse with revolving apses; this suggestion receives support from the discussion of the observations between 1889 and 1894, during which years special observations have been made under the direction of the International Geodetic Association. A brief account of the special series at Kasan and Karlsruhe and at Strassburg and Bethlehem was given by Dr. Förster at the meeting of the British Association at Oxford, and the full report by Professor Albrecht has been published. Some valuable observations were also made at San Francisco by Professor Geo. Davidson. Mr. Chandler's papers are printed, as before, in the *Astronomical Journal.*

*New Observatories.*

Recently several new Observatories have been established and changes made in others. Mr. Percival Lowell, a citizen of Boston,

has built an observatory for himself, longitude 112° W., latitude 35° N. in the territory of Arizona, near the town of Flagstaff, at an elevation of 7300 feet above the sea. This site is said to be higher than that of any large observatory in the Northern hemisphere. The equipment consists mainly of two telescopes with object glasses, respectively of 18 inches and 12 inches aperture, mounted as a twin instrument on an equatorial mounting. It is purposed to use the larger of these for spectroscopic and general eye observations, and the smaller for photography. The scheme of work laid down by Mr. Lowell for the observatory is chiefly the examination of planetary detail, and he and his assistants, Professor W. H. Pickering and Mr. Douglass, have published extensive reports of observations of *Mars* in recent numbers of *Astronomy* and *Astro Physics.* Another of the institutions referred to above is the Manora Observatory, Lussinpiccolo, Austro-Hungary, under the direction of Herr Leo Brenner, who has for his use a 7-inch refractor by Reinfelder and Hertel, with which he observes the details of lunar and planetary surfaces.

The Dudley Observatory, Albany, U.S.A., which was established in 1857, under the direction of Dr. B. A. Gould, has recently been transfered to a new site. Several reasons, among which was the proximity of a railroad, conspired to make the transference advisable, and a liberal donation by Miss Catherine Bruce, together with the proceeds of a public subscription, provided funds for building a new observatory on a site given by the City of Albany in exchange for the former grounds and buildings. The new site is in the western part of Albany, but its geographical coordinates are not known with great certainty. The adopted longitude of the transit circle is $4^{h}\ 55^{m}\ 6^{s}\cdot8$ W., latitude 42° 39′ 12″·7 N. The old observatory was abandoned in June 1893, at which time the new buildings were nearly ready for use. The instruments were then transferred, and were arranged ready for observation by the beginning of 1894. The transit circle is the Olcott Meridian Circle, which had been used in the old observatory since its foundation, and with which the observations for the zone-catalogue contributed by Albany to the catalogue of the *Astronomische Gesellschaft* were made. This instrument is described in the Introduction to the Albany Zone-Catalogue. A new equatorial telescope has been provided by funds supplied by the sons of the late R. H. Pruyn, formerly President of the Observatory Trustees. This telescope of 31 cm. aperture, made by the firm of Warner and Swasey, Mr. Brashear supplying the optical parts, has been actively used since 1894 March 29 for observation of position of comets and small planets.

A powerfully equipped observatory has recently been formed at Manila in the Philippine Islands, in latitude about 14° N., where there has been for some years a meteorological and seismographic observing station. The observatory is under the direction of Father Algué, and owns an equatorial having an object glass by Merz of 19·2 English inches in diameter, and provided

with a photographic correcting lens, which is to be used for photographic, spectrographic, and visual work on stars. The work immediately in hand is the making of observations for the determination of variation of latitude, in connection with similar work by Fathers Hagen and Fargis at Georgetown College Observatory. The instrument used for this at Manila is the Reflecting Zenith Telescope with two objectives, described in *Monthly Notices*, vol. liv. p. 264. No observations have yet been published from this observatory.

Dr. Lewis Swift, formerly of the Warner Observatory, Rochester, U.S.A., is now in charge of an observatory lately erected by Professor T. S. C. Lowe, Echo Mountain, Southern California, sixteen miles north-east of Los Angeles, and about 3500 feet above sea-level. The equipment of this observatory consists of the 16-inch Clark refractor and other instruments which have been used by Dr. Swift at Rochester. A noteworthy incident at this young institution has been the finding of a comet by Edward Swift, son of the director.

A note in the *Astronomische Nachrichten*, No. 3232, published in June last, announced that the Observatory at Karlsruhe was to be abandoned, and its instruments to be used in furnishing a new observatory at the University of Heidelberg, of which Professors Valentiner and Max-Wolf were to be directors respectively of the astronomical and astrophysical departments.

H. P. H.